

vehicles destroyed by ATACMS missiles would be combat vehicles. Using IDA's higher estimate of missile effectiveness, this would represent the destruction of between 247 and 578 combat vehicles per division, or 30 percent to 70 percent of a division's combat power. Based on Canby's estimates, however, an attack by 330 ATACMS missiles would result in destruction of only 5 percent to 30 percent of a Pact division's combat capability. Inasmuch as this study attempted to weigh the value of FOFA versus other alternatives, CBO used the more conservative range of capabilities (represented by Canby's analysis) as a basis for estimating the capability of each ATACMS missile. Thus, an average of 20 percent loss of combat capability was assumed to result in each Pact division subject to attack by 330 ATACMS missiles.

The actual impact of FOFA, theaterwide, is a function not only of how well the weapons and supporting sensors work, but also how the Warsaw Pact structures and schedules its attack. If the Warsaw Pact were to attack West Germany shortly after it started to mobilize--say, within four days--then many reinforcing Pact units would still be in transit at the onset of hostilities. Indeed, in the middle-range scenario discussed in Chapter II, 59 Pact divisions could be attacked before they reached the front during the first 30 days of combat if attacks of follow-on forces started four days after the Warsaw Pact began to mobilize ( $M+4$ ). If attacks continued until all reinforcing Pact units arrived at the front ( $M+81$ ), then 24 additional Pact divisions would come under attack.

Even if the Pact waits until more of its forces have arrived in theater to initiate hostilities--for instance, 15 days after mobilization (or  $M+15$ )--opportunities still exist for deep attack of almost 31 Pact divisions. Many analysts believe, however, that even with those forces in theater, the Warsaw Pact will structure an attack in waves or echelons, holding a significant portion of their forces in reserve and away from the front lines. Using the distribution of Pact divisions previously postulated by the Department of Defense in a 1979 study, this could allow NATO to attack 70 reinforcing Pact divisions, even if

attacks were not initiated until M+15.<sup>10</sup> Fifty-three of these reinforcing divisions could be attacked during the first 30 days of combat. This last attack structure, starting at M+15 and conducted in waves or echelons, is the basis for most of the analysis discussed in Chapter III.

### Risks

Actually achieving a high rate of destruction among enemy units is a complex process fraught with risks. The missile must fly long distances to the actual position of the intended target. Since the data relay and missile flight out to 80 kilometers within enemy territory could take several minutes, the target position must be continuously updated or predicted from the target's last known location, direction, and speed. Depending on the type of sensor, each submunition will be able to "search" only a limited amount of ground after it is dispensed from the ATACMS missile from a height of several hundred meters. The missile must therefore arrive close enough to the target so that when it dispenses its submunitions, they will be able to locate individual enemy vehicles. As the submunition falls to the ground (usually slowed by a small parachute or umbrella-like structure), its sensor attempts to detect the heat from a tank engine or a radar return from the vehicle itself, depending on the type of submunition. Once a target is detected, the submunition glides toward it and explodes on impact. If it detects nothing, the submunition falls to the ground.

It is unlikely that all of the submunitions carried by a particular ATACMS missile will find individual vehicles to attack as they fall. Indeed, the missile carrying the submunitions could be so far off course that none of the submunitions will find targets. Furthermore, there have been very few tests to date of such missiles and their submunitions. Moreover, none of the tests has been conducted in realistic conditions similar to those that would be found in combat in Europe.

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10. This distribution would assume that the Warsaw Pact would put only one ADE (or approximately 1.7 Pact divisions) up front for every 11 kilometers of front in the main corridors of attack. All other reinforcing units would be held in successive echelons. See Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979).



## GLOSSARY

### SELECTED WEAPONS SYSTEMS

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Included in the following sections are descriptions of selected weapons systems used by NATO and the Warsaw Pact.

#### AIRCRAFT

A-10. The A-10 was developed by the United States specifically for the close air support mission. It is heavily armored and incorporates many features to enhance its survivability in the high-threat area over the battlefield. The aircraft has a 30-millimeter (mm) gun for attacking tanks and other armored vehicles and can carry up to 16,000 pounds of bombs and missiles. A-10s were last bought in 1982, and the bulk of the inventory is now about eight years old.

B-52. The B-52 is currently the backbone of the United States' strategic bomber force. First flown in 1952, the last B-52 was produced in 1962. Powered by eight engines and carrying a crew of six, the B-52's maximum speed is 1,050 kilometers per hour. The remaining B-52s are being reconfigured to carry cruise missiles, rather than gravity bombs.

F-4. The F-4 is a two-seat, twin-engine, supersonic aircraft capable of performing both air-to-air and air-to-ground missions. It was originally designed for the Navy, which received its first F-4 in 1960. The F-4 was later also bought by the U.S. Air Force, which eventually procured five models of the aircraft (about 2,300 combat aircraft and 500 reconnaissance planes). About 1,160 combat aircraft are still in the Air Force inventory.

F-15. The F-15 is a twin-engine, single-seat aircraft designed specifically for high maneuverability in air-to-air combat. It is the U.S. Air Force's most sophisticated fighter aircraft and is equipped with advanced radar that allows it to perform its mission in day or night and under all weather conditions. A new version, the F-15E, will be able

to perform ground-attack as well as air-to-air missions and will first be fielded in 1989.

F-16. The F-16 was developed in the late 1970s. A comparatively small aircraft, with only one engine and only one seat in the cockpit, the F-16 is considered a "swing-role" aircraft, performing both air-to-air and ground-attack missions for the U.S. Air Force. It lacks the range to perform the deep interdiction mission, however, and does not have the advanced avionics necessary to operate at night or in bad weather. Nonetheless, the F-16 can perform the ground-attack missions of battlefield interdiction and close air support.

F-111. The F-111 is devoted exclusively to ground attack. It has movable or "variable geometry" wings that optimize its aerodynamic shape under different flight conditions. The aircraft is equipped with a radar system for bombing and also with automatic terrain-following radar that allows the pilot to fly at low altitude without being able to see the ground. These advanced avionics allow the aircraft to carry out its mission at night or in foul weather. The last production model was delivered to the U.S. Air Force in 1976.

MiG-21 Fishbed. The MiG-21, one of the most widely used fighters in the world, was developed in the mid-1950s. This single-seat jet aircraft can fly at speeds up to 2,230 kilometers per hour and has a combat radius of 370 kilometers when carrying four 550-pound bombs. Approximately 700 MiG-21s are still in service with the Soviet tactical air forces.

MiG-23 Flogger. First deployed with the Soviet air forces in large numbers in 1973, this variable-geometry aircraft is currently in service with all Warsaw Pact air forces. The MiG-23 has a maximum speed of 2,500 kilometers per hour and a combat radius of 900 to 1,200 kilometers. Approximately 1,780 Floggers were serving with the Soviet air forces in 1986.

Su-22 Fitter. This variable-geometry, ground-attack aircraft was first seen as a prototype in Moscow in 1967 and has since been exported to Poland and Czechoslovakia for fielding with their air forces. The Su-22 can fly at speeds up to 2,200 kilometers per hour and has a combat radius of 250 to 345 kilometers.

Su-25 Frogfoot. The Frogfoot is the Soviet counterpart to the U.S. A-10 close air support aircraft. Although a few of these aircraft were deployed to Afghanistan in 1982, the Su-25 did not reach full operational capability until 1984. This two-engine, single-seat aircraft can fly at speeds up to 880 kilometers per hour and has a combat radius of 556 kilometers.

## AIR DEFENSE

Air Defense Antitank System. Designed in Switzerland, ADATS is a missile system that is being fielded with Canadian and U.S. forces. The U.S. version is carried on a lightly armored, tracked vehicle. ADATS is designed primarily to destroy aircraft and helicopters, but can also engage tanks and other armored vehicles. Each ADATS launcher includes a target-finding radar and an optical tracking system. The ADATS missile has an effective range of eight kilometers. The development test phase was completed in mid-1984.

Division Air Defense Gun. Production of the DIVAD began in 1982 but was terminated in August 1985. Designed to provide the U.S. Army's forward combat units with low-altitude air defense coverage, the DIVAD gun was scheduled to replace the current Vulcan air defense gun. Whereas the Vulcan has a 20mm gun with an effective range of 1,200 meters, the DIVAD included twin 40mm guns with an effective range of 4,000 meters.

Vulcan. The Vulcan air defense system, first introduced into U.S. Army units in 1968, consists of a six-barrel 20mm "Gatling" gun. Its effectiveness is limited to good weather conditions and a range of 1,200 meters. In armored divisions, the Vulcan is mounted on a lightly armored carrier; in other units, it is towed.

## ARTILLERY

### Howitzers

M109 155mm Howitzer. The M109 howitzer has been in service with the U.S. Army since 1963. The 155mm cannon is mounted on an aluminum-armored, tracked vehicle that carries a crew of six. The

M109 can fire up to one round every minute continuously for periods as long as an hour; its maximum range is 18 kilometers. The vehicle has a maximum road speed of 55 kilometers per hour and a cruising range of 350 kilometers.

M110 8-inch Howitzer. Developed by the U.S. Army starting in the late 1950s, the M110, in various versions, is in service with many of NATO's armies, including those of the United States, Belgium, West Germany, Greece, Italy, the Netherlands, Spain, Turkey, and the United Kingdom. The A1 version, which is widely fielded with the U.S. Army, has an 8-inch gun that is mounted on a tracked vehicle with a maximum road speed of 56 kilometers per hour and a cruising range of 725 kilometers. The crew of five can fire up to 30 rounds per hour, with a maximum range of 20,600 meters.

2S1 122mm Howitzer. First fielded with Soviet and Polish forces in the early 1970s, the 2S1 howitzer is mounted on a tracked vehicle with a maximum road speed of 60 kilometers per hour. Carrying a crew of four, the 2S1 can fire up to three rounds per minute for prolonged periods of time to a maximum range of 15,300 meters. This howitzer is currently fielded with all Warsaw Pact armies in the European central region.

2S3 152mm Howitzer. The 2S3 howitzer includes a 152mm cannon that is mounted on a tracked vehicle and has a maximum firing range of 24 kilometers. It entered service with the Soviet forces in the early 1970s and is currently also fielded with the East German army. The howitzer's crew of three to six can fire two rounds per minute over a sustained period.

### Multiple Rocket Launchers

Multiple Launch Rocket System. The MLRS is an artillery rocket system designed to counter enemy artillery and air defenses. Each rocket can carry hundreds of small cluster munitions. The MLRS was initially fielded in U.S. Army units in early 1983.

BM-21 122mm Multiple Rocket Launcher. First seen publicly in Moscow in 1964, the BM-21 has since become the Soviet army's standard multiple rocket launcher. Mounted on a standard truck chassis,

the BM-21 has 40 launch tubes arranged in four rows. A 40-rocket salvo can be fired in a few seconds. Each rocket has a range of 20,500 meters, and the entire launcher can be reloaded in 10 minutes.

### Mortars

M224 60mm Lightweight Company Mortar. This mortar, designed specifically for use by U.S. infantry companies, can be set up and fired by a single soldier without assistance. Weighing only 46.5 pounds, it can fire charges to a maximum range of 3,490 meters. The U.S. Army has fielded more than 1,590 of these mortars.

M252 81mm Mortar. This medium-range (up to 5,600 meters) mortar will replace the older version--the M29 81mm mortar--currently fielded with the U.S. light infantry, airborne, and air assault divisions. The mortar, which weighs 91 pounds, is operated by a crew of five and can fire up to 15 rounds per minute. The United States started buying the M252 in 1985 and began fielding it two years later.

M30 107mm Mortar. The M30 is no longer in production but is still fielded with U.S. mechanized infantry units and armored cavalry regiments. A heavy--almost 700 pounds--weapon that can be hand-carried for only short distances when broken down into five pieces, the M30 can lob rounds out to ranges of 6,800 meters. The Army has expressed interest in developing a lighter 120mm mortar to replace it.

M-1937 82mm Mortar. The M-1937 is widely fielded with most Warsaw Pact armies. The mortar weighs 123 pounds and it can be towed behind a truck or armored personnel carrier. The M-1937 requires a crew of five to operate it, and it can lob 15 to 25 rounds per minute to a maximum range of 3,040 meters.

M-1943 120mm Mortar. The M-1943 has been the standard mortar in the Soviet forces since World War II. Six mortars are currently deployed with each motorized rifle battalion. A crew of six operates this 606-pound mortar, which can be towed behind a truck or armored personnel carrier. A sustained firing rate of up to 100 rounds per hour can be maintained over long periods of time, while a maximum rate of 12 to 15 rounds per minute is possible for short periods. The maximum range of the M-1943 is 5,700 meters.

## HELICOPTERS

AH-1S Cobra Helicopter. The AH-1G Cobra saw extensive combat duty in Vietnam as an attack helicopter. The latest version, the AH-1S, is equipped with TOW missiles, rockets, and a 20mm machine gun. Unlike the more modern AH-64, the AH-1S is limited primarily to operating in fair weather.

AH-64 Apache Helicopter. The Apache is the U.S. Army's most modern attack helicopter and permits its crew of two to attack in darkness and in adverse weather. The AH-64 carries 16 Hellfire antitank missiles, which can home in on a target designated by a laser beam. The AH-64 also carries a 30mm gun and 2.75-inch rockets. Production began in 1982, with procurement of 675 AH-64s planned through 1989.

HIND E. A Soviet-built attack helicopter, the HIND E is equipped with a large-caliber machine gun and 57mm rockets. It is believed to carry, in addition, up to four antitank missiles with a range of eight kilometers. The HIND helicopter has been deployed since 1974 in Warsaw Pact armies.

## MISSILES

### Antitank--Launched from Aircraft

Hellfire Missile. Designed to be carried on the AH-64 helicopter, the Hellfire homes in on a target that has been designated by a laser beam; this designation can be made by other aircraft as well as by ground observers. Current plans call for a "follow-on seeker" that will permit the missile to find its target without any external designation--a "fire and forget" capability.

Maverick Air-to-Surface Missile System. The Maverick is a precision-guided, tactical missile for use against hardened targets such as tanks, armored vehicles, and field fortifications. The latest version, carried by the U.S. Air Force's F-16 aircraft, is guided to its target by heat emissions.

Tube-Launched, Optically Tracked, Wire-Guided (TOW) Antitank Missile. Carried on the Bradley fighting vehicle, the AH-1S attack helicopter, and the improved TOW vehicle, the TOW missile's warhead can penetrate the front--where the armor is generally the thickest--of the majority of the world's main battle tanks. It has an effective range of 3,750 meters. Once launched, it must be guided by a gunner, who maintains the cross hairs of the sight on the target. As the gunner tracks the target, a computer in the launcher sends corrections to the missile through fine wires. The TOW missile has been in the Army's inventory for many years; current plans call for improvements in the lethality of the warhead to ensure the weapon's effectiveness into the 1990s.

#### Antitank--Medium-Range, Ground-Launched

Bill Antitank Missile. The Bill is a wire-guided, command-to-line-of-sight weapon--similar to the Dragon and Milan (see below)--with an effective range of 150 to 2,000 meters. The Bill is unique, however, in that it flies slightly above its intended target and fires a slug downward toward the top of the enemy tank. Since the armor protection is usually thinner on the top of a tank, Bill's angled warhead is claimed to give the missile a higher kill probability. It was initially fielded in Sweden in 1986.

Dragon. The Dragon is a medium-range, wire-guided, antitank missile light enough to be carried by a soldier. It has an effective range of 1,000 meters. Once launched, it must be guided by the gunner, who maintains the sight on the target. As the gunner tracks the target, a computer in the launcher sends corrections to the missile through fine wires. The Dragon is deployed in Army units and is no longer in production.

Milan. The Milan is a wire-guided, antitank missile system that can be carried by two soldiers. The improved version, Milan 2, incorporates a guidance system similar to that of the Dragon, which requires the gunner to maintain the cross hairs of the sight on the target during the missile's flight. It has an effective range of 2,000 meters and was first fielded in the early 1970s.

### Antitank--Short-Range, Ground-Launched

AT-4. The AT-4 is a recently developed, shoulder-fired, antitank weapon that the U.S. Army is buying to replace the Light Antitank Weapon (LAW) in some of its units. Originally designed in Sweden, the AT-4 has a bigger and heavier warhead than the LAW and is therefore able to penetrate an additional 145 millimeters of armor plate.

Light Antitank Weapon. The LAW is the U.S. Army's most widely fielded modern version of the World War II bazooka. It is a one-shot, low-cost, shoulder-fired antitank weapon with an effective range of 300 meters.

### Other Missiles

Army Tactical Missile System. The ATACMS is a U.S. system designed for deep attack of enemy forces at a range beyond that of current rockets and artillery. The ATACMS is a ballistic missile to be fired from a modified MLRS (Multiple Launch Rocket System) launcher. The missile will use an inertial system to guide it accurately to the area where submunitions will be dispensed from the warhead section. The current version will carry small dual-purpose bombs that are effective against both personnel and equipment. A later version will carry submunitions that are capable of destroying armored vehicles. Formally started in 1983 as the Joint Tactical Missile System (JTACMS), the project combined earlier programs carried out separately by the Army and the Air Force. In mid-1984, the Air Force ended its participation, and the Army continued the program and changed the name. Production of the first version will start in 1989.

Cruise Missiles. The U.S. cruise missile program includes the air-launched cruise missile (ALCM), the ground-launched cruise missile (GLCM), and the sea-launched cruise missile (SLCM). The ALCM provides the Air Force with an air-launched strategic weapon for deployment on the B-52 and B-1 bombers. The ALCM, which was initially fielded in 1982, is intended for high-speed cruise flight at low altitudes for distances of up to 2,500 kilometers. The GLCM consists of a cruise missile incorporated in a ground launcher mounted on a truck. It has an effective range of 2,500 kilometers and can be used for nuclear attacks on fixed targets such as logistics facilities and air-

fields. The GLCM was initially fielded in 1984, but all versions are due to be destroyed under the terms of the Intermediate-Range Nuclear Forces Treaty. SLCMs are designed for launch from submerged submarines or from surface ships. Designed for both land attack and antiship missions, the SLCM uses either nuclear or conventional high-explosive warheads and different guidance systems, depending on the mission. Its ground-attack range is 2,500 kilometers, while that of the antiship version is 450 kilometers. It was initially fielded in 1984.

## SURVEILLANCE SYSTEMS

Advanced Synthetic Aperture Radar System II. The Air Force's ASARS II is a high-resolution radar designed to detect stationary objects on the ground. It can be carried by the TR-1 aircraft (described below).

Joint Surveillance and Target Attack Radar System. A battle management and targeting system, JSTARS is a joint program of the Air Force and Army. The radar is mounted on a military version of a Boeing 707 and is intended to detect enemy vehicles on the battlefield. The entire system--which includes the radar, on-board operators' consoles, and ground stations--is designed to direct attacks against moving ground targets by low-flying aircraft and missiles. The radar's detection range is expected to be up to 300 kilometers into the enemy's territory. JSTARS is currently in full-scale engineering development.

OV-1D (Mohawk) Surveillance System. The OV-1D is a two-seat, twin-turboprop, combat aircraft equipped with side-looking airborne radar and photographic or infrared sensors capable of monitoring enemy operations in daylight, darkness, and adverse weather.

TR-1 Aircraft. The TR-1 is a small single-engine aircraft designed to carry reconnaissance payloads such as photographic equipment or radars. It is designed to fly at very high altitudes for long periods of time and is a modified tactical version of the well-known U-2 aircraft.

## TANKS

M1/M1A1 Abrams Tank. The Abrams tank is the U.S. Army's premier battle tank. Both versions of the M1 are equipped with special armor, a laser rangefinder, and a 1,500-horsepower turbine engine. The M1A1, which is now being produced, incorporates a 120mm main gun that has a higher muzzle velocity and longer range than the original 105mm version on the M1. The Army purchased about 3,270 M1 tanks equipped with the smaller gun. About 1,900 M1A1s have been produced so far, with 2,700 more planned by the mid-1990s.

M60A1/M60A3 Tank. The M60A1 tank was first deployed in the early 1960s and was later followed by an improved version, designated the M60A3. Enhancements to the M60A1 that are included in the M60A3 are a laser rangefinder and a solid-state fire control computer. These two models account for the bulk of U.S. tanks currently deployed with Army units. Production of the M60A3 tank was completed in 1983, and the United States has no plans to produce more.

Chieftain Tank. The Chieftain is the most prevalent tank in the British army, 900 having been produced between 1963 and the early 1970s. The tank is equipped with a 120mm gun, weighs 61 tons, and has a maximum road speed of 48 kilometers per hour. The fire control system has undergone several improvements since the tank was first designed in the early 1960s.

T-64 Tank. First fielded with Soviet units in 1967, the T-64 was in production through the early 1980s. Almost 11,500 T-64 tanks, in various versions, are assumed to be in service today. The T-64 is equipped with a 125mm cannon, weighs 42 tons, and has a maximum road speed of 70 kilometers per hour.

T-72 Tank. The T-72 entered production in 1971 and is simpler in design and production requirements than the T-64. As a consequence, the T-72 has been widely fielded with non-Soviet Warsaw Pact forces, whereas the T-64 is found exclusively in Soviet units. Also equipped with a 125mm gun, the T-72, at 45 tons, weighs more than the T-64 and has a slightly slower maximum road speed of 60 kilometers per hour. Approximately 8,100 T-72s are currently believed to be in service throughout the Warsaw Pact.

T-80 Tank. The latest version of the Soviet (hence Warsaw Pact) main battle tank, the T-80, will replace the current T-72 built in the early 1970s and the T-64 built even earlier. The T-80 is believed to have a 125mm main gun, an automatic loader, and a laser rangefinder. The T-80's special armor may be the major improvement of this tank, relative to the T-72.

## VEHICLES AND ARMORED PERSONNEL CARRIERS

Bradley Fighting Vehicle. The Bradley fighting vehicle is the U.S. Army's latest armored personnel carrier. It includes a two-person turret with a 25mm cannon mounted on a lightly armored, tracked chassis. The Bradley also carries a TOW antitank guided missile launcher. Initial production began in 1980.

M113. The M113 is an aluminum-armored personnel carrier designed to transport troops, equipment, and cargo during combat operations. It can carry 11 soldiers at a maximum cross-country speed of 30 kilometers per hour. The only armament carried on the M113, which entered production in 1960, is a 50-caliber (12.7mm) machine gun. The U.S. Army currently owns more than 26,000 of these vehicles.

Ferret Reconnaissance Vehicle. The Ferret is a wheeled, lightly armored reconnaissance vehicle in service with the British Army. It carries a crew of two or three and can be equipped with various kinds of light armament. The first model was produced in 1952, and the last of more than 4,400 Ferrets was delivered in 1971.

BMP. A Soviet-built armored fighting vehicle, the BMP is equipped with a 73mm automatically loaded gun that will fire a high-explosive antitank round. The BMP has been in production since the late 1960s, and it is deployed in significant numbers in Warsaw Pact armies.

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